Chapter 3

Potential Demand for Natural Gas By Country

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Chapter 3

Potential Demand for Natural Gas By Country

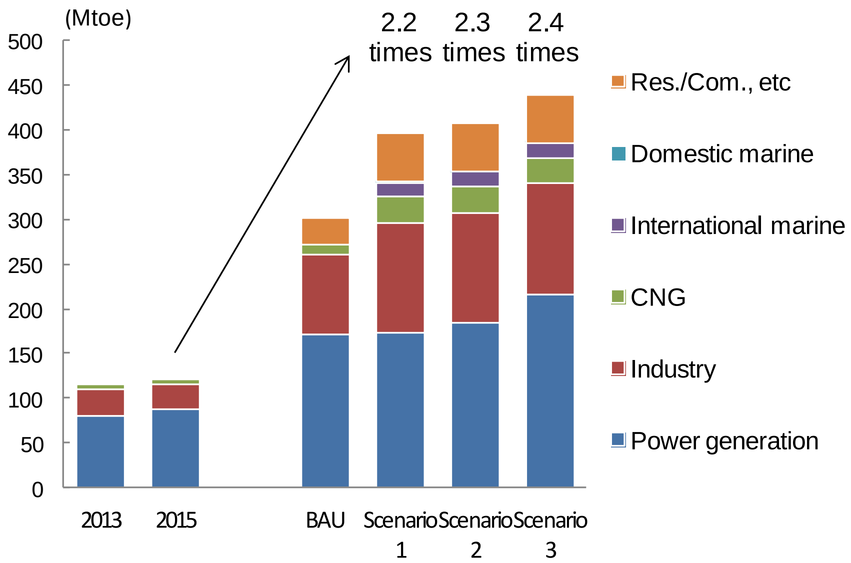
This chapter describes the potential demand for natural gas by country based on the assumptions enumerated in Chapter 2. It also explains the impact of the potential demand for natural gas on the economy in comparison to the BAU scenario. It should be noted, however, that this report's preliminary study found it difficult to establish the potential demand for natural gas in the Lao PDR[4].

3.1 ASEAN + India

3.1.1 Potential demand for natural gas by sector

Figure 3.1 shows potential demand for natural gas by sector in ASEAN + India. The potential demand for natural gas by the year of 2030 is estimated to increase by up to 322 Mtoe compared to the 2015 level. The power generation sector has the largest potential demand for natural gas, followed by the industry sector.

Figure 3.1. Potential Demand for Natural Gas by Sector, ASEAN + India



Notes: BAU = business as usual; CNG = compressed natural gas

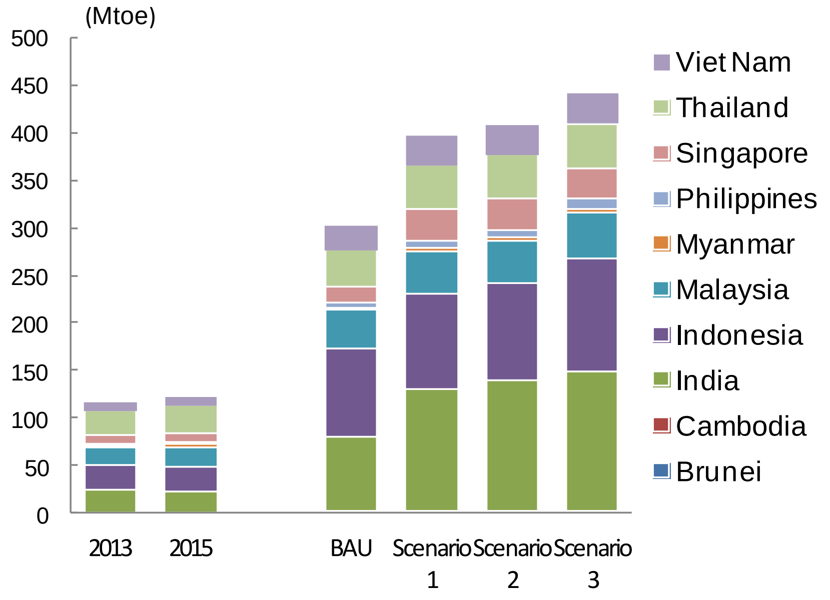
[4] That is, there is no room to introduce GPP because the Lao PDR has abundant hydro power to export.

Furthermore, the demand in its Other Sectors is too small, and the source of the demand is too far from coastlines where natural gas is found. Thus, meeting the demand with gas-fired power stations will entail considerable infrastructure investment.

3.1.2 Natural gas demand by country

On the other hand, Figure 3.2 demonstrates the potential demand for natural gas by country. India holds the largest potential demand for natural gas, followed by Indonesia.

Figure 3.2. Potential Demand for Natural Gas by Country, ASEAN + India

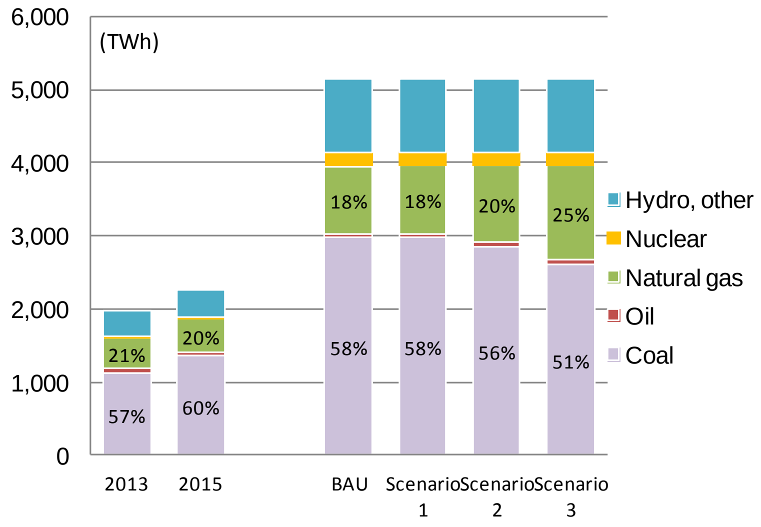


BAU = business as usual.

3.1.3 Power generation structure

Figure 3.3 shows the estimated power generation mix for ASEAN + India. While the share of natural gas-fired power generation was 20% in 2015, a decrease to 18% is expected in 2030 under the BAU scenario. In contrast, Scenario 3 estimates show that the share of natural gas-fired power generation in 2030 will exceed the share in 2015.

Figure 3.3. Power Generation Mix, ASEAN + India



BAU = business as usual.

3.1.4 Cost and CO_2 emission comparisons

The economic impact on costs and CO_2 emissions are then analysed based on the following assumptions:

- Input fuel (coal, oil, and natural gas) is priced at international levels;
- Estimates on the economic impact of oil and natural gas are based on that of crude oil and LNG, respectively;
- Power generation sector
    - ❖ Heat efficiency: Coal = 40%, Natural gas = 50%; and

      Power generation (TWh) /heat efficiency = required input energy
    - ❖ Capacity utilization rate: 60%; and

      Power generation (TWh)/365 (days)/24 (hours)/60%

      = required power generation capacity

Results of the impact are then compared with that of the BAU scenario.

Table 3.1 presents costs by scenarios and by LNG prices in the power generation sector, and a comparison of CO_2 emissions. The positive values represent emission increases, while the negative values represent emission decreases. In the power generation sector, CPP and GPP are compared.

Table 3.1. Cost, CO_2 Emission (Power Generation), ASEAN + India

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	+0.7	+0.5	+0.4	+0.1	+6.4 (+0%)
2	+7.5	+4.9	+2.2	-0.5	-55.8 (-2%)
3	+20.7	+13.3	+5.6	-1.7	-176.5 (-6%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

The heat efficiency of GPP is higher than CPP, and the required input energy of GPP is smaller than CPP. However, the coal price (US$125/toe) is very low compared to the LNG price, which is US$6/MMbtu (US$238/toe) at its lowest. Therefore, the fuel cost increases under all the scenarios, as shown in Table 3.1.

Since the power plant construction cost for GPP is lower than CPP, there will be a benefit under all the scenarios. The increase in the construction cost in Scenario 1 is based on the assumption for nuclear power generation in Viet Nam. In other words, the BAU scenario for Viet Nam assumes that an NPP will commence operation in 2028. However, in this study, no NPP is assumed to commence operation even in 2030. This is because the NPP power generation equivalent under the BAU scenario is assumed to be replaced with thermal power generation. Neither CPP nor GPP are an alternative to NPP as power generation equivalents, although both will increase on a net basis. Obtaining the estimates on the NPP construction cost is quite difficult; thus, only TPP construction cost increases are considered in this study.

Since the specific CO_2 emission of GPP is lower than that of CPP, the CO_2 emission should decrease in general in all scenarios. The increase in CO_2 emission in Scenario 1 is due to the assumption that TPPs will replace NPPs in Viet Nam.

Under Scenarios 2 and 3, the impact of replacing NPPs with TPPs in Viet Nam is offset by an increase in GPPs as compared to that in Scenario 1.

In sectors other than in power generation, oil will be replaced by natural gas. Even if the LNG price is US$11.9/MMbtu (US$472/toe), it is lower than the crude oil price (US$820/toe); therefore, there will be a net saving on the fuel cost. In addition, the specific CO_2 emission from natural gas is lesser than that from oil.

Table 3.2. Cost and CO_2 Emission (Other Sector Total), ASEAN + India

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-23.9	-34.6	-45.6	-0.048 (-2%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

If all the potential demand for natural gas is met, there will be a net saving as well in the total calculated fuel cost for all sectors even if the LNG price is US$11.9/MMbtu.

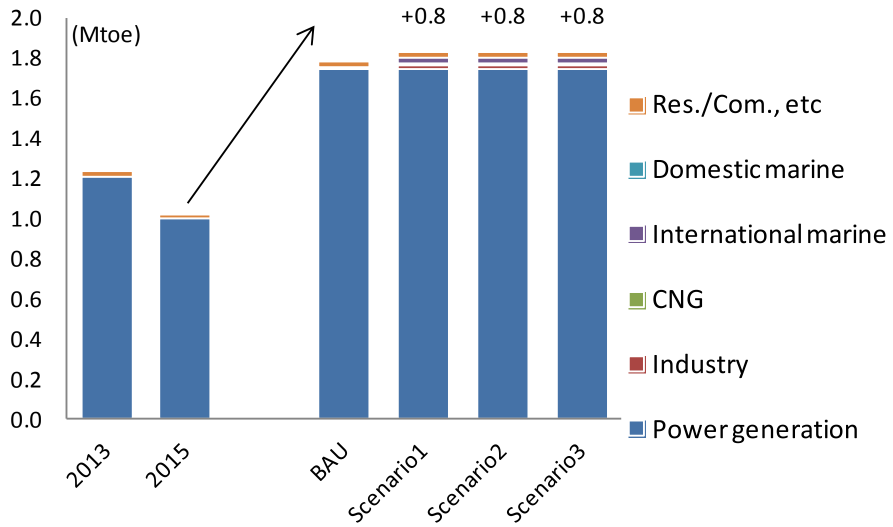
The next subsections present the results by country.

3.2 Brunei Darussalam

3.2.1 Potential demand for natural gas by sector

Figure 3.4 shows that the power generation sector has the highest potential domestic demand for natural gas.

Figure 3.4. Potential Demand for Natural Gas by Sector (Brunei Darussalam)

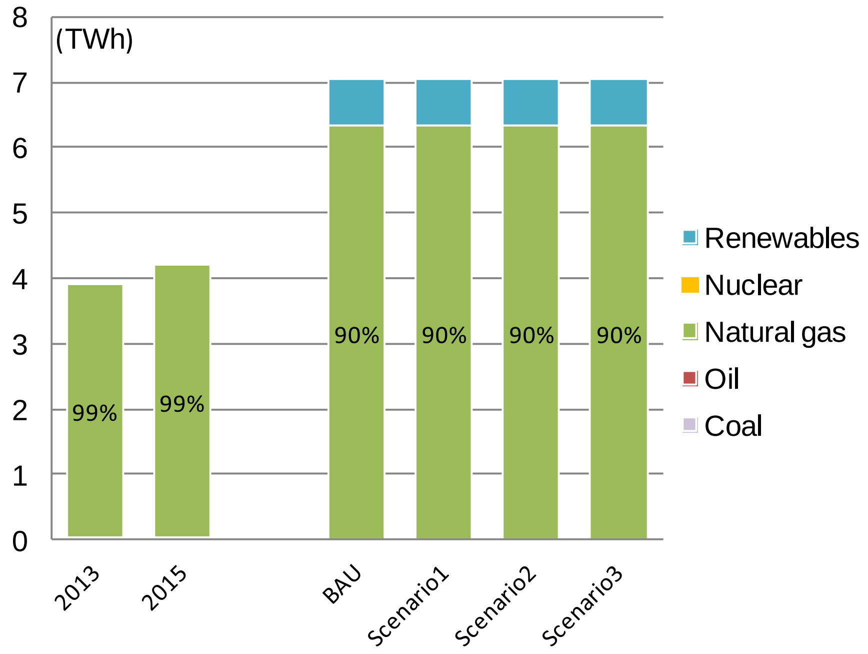


Notes: BAU = business as usual; CNG = compressed natural gas.

3.2.2 Power generation structure

Figure 3.5 reveals the estimated power generation mix for Brunei. The nation has a high natural gas share, and all of the three scenarios have similar results as that of the BAU scenario.

Figure 3.5. Power Generation Mix, Brunei Darussalam



BAU = business as usual.

3.2.3 Cost and CO_2 emission comparisons

The impact of the potential demand for natural gas on the cost and CO_2 emissions are estimated as an increment or decrement of carbon emissions from coal, oil, and natural gas in comparison to the BAU scenario.

As mentioned earlier, Brunei has a very high GPP ratio, and the potential demand for natural gas in the power generation sector corresponds to the BAU scenario. Therefore, only sectors other than the power generation sector are compared in this study.

In sectors other than the power generation sector, oil will be replaced by natural gas. Even if the LNG price is US$11.9/MMbtu (US$472/toe), such is still lower than the crude oil price (US$820/toe) and, therefore, presents a large saving in the fuel cost. In addition, natural gas has lesser CO_2 emission than oil.

Table 3.3. Cost and CO_2 Mission (Other Sectors), Brunei Darussalam

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-0.002	-0.002	-0.003	-0.00002 (-1%)

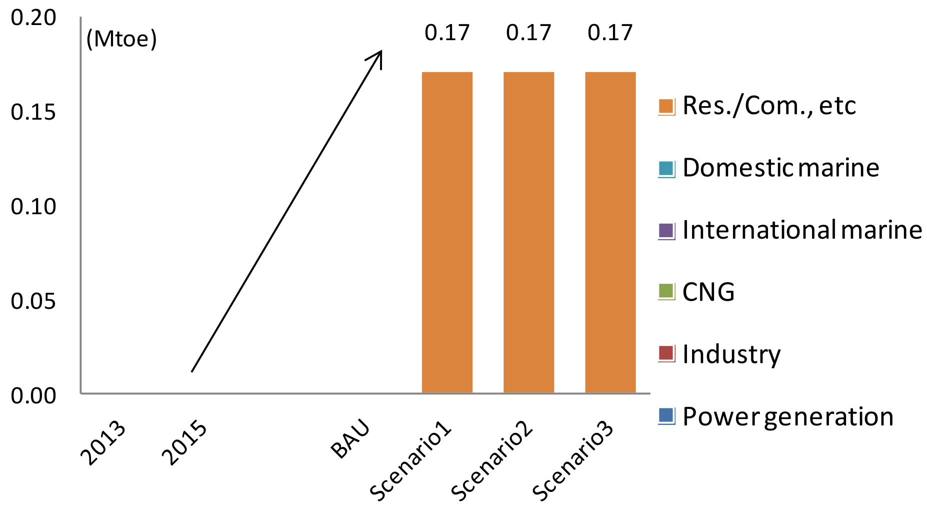
LNG = liquefied natural gas; CO_2 = carbon dioxide.

3.3 Cambodia

3.3.1 Potential demand for natural gas by sector

Under the BAU scenario for Cambodia, there is no natural gas demand. In this study, the assumption is that potential demand for natural gas exists in the residential and commercial sectors.

Figure 3.6. Potential Demand for Natural Gas by Sector, Cambodia



Notes: BAU = business as usual; CNG = compressed natural gas.

3.2.2 Cost and CO_2 emission comparisons

In the case of Cambodia, sectors other than the power generation sector are compared in this study. Here, oil will be replaced by natural gas. At US$11.9/MMbtu (US$472/toe), the LNG price is lower than the crude oil price (US$820/toe), and therefore, presents a large advantage in fuel costs. Also, the CO_2 emitted by natural gas is lesser than that by oil.

Table 3.4. Cost and CO_2 Emission (Other Sectors), Cambodia

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-0.06	-0.08	-0.10	-0.00005 (-0%)

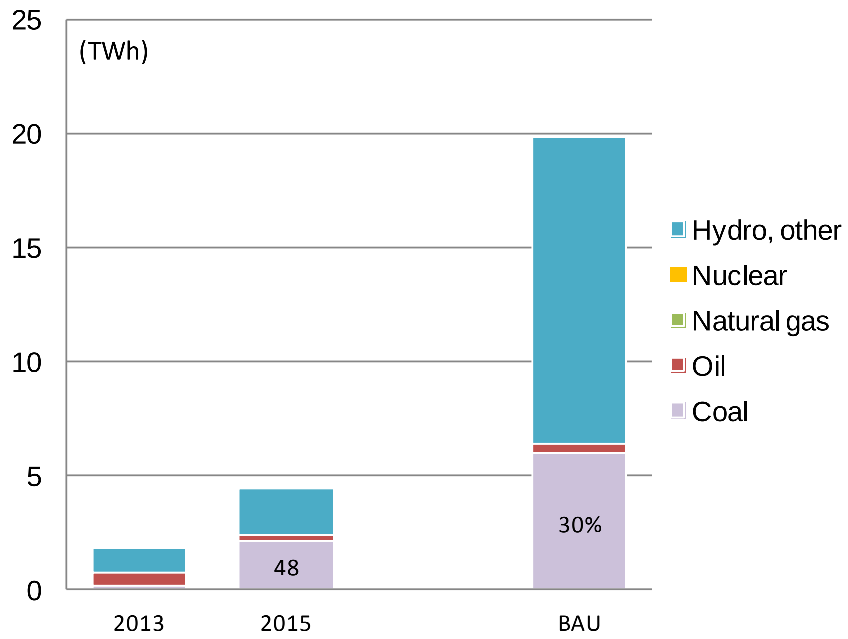
LNG = liquefied natural gas; CO_2 = carbon dioxide.

Power generation structure (Reference)

Figure 3.7 estimates the power generation mix for Cambodia under the BAU scenario as a reference.

Under the BAU scenario, 30% of Cambodia's power generation is assumed to be attributed to CPPs. The CPP power generation under the BAU scenario can be covered by the nation's existing CPP capacity. New hydro power represents much of the country's additional power generation aside from CPP.

Figure 3.7. (Reference) Power Generation Mix, Cambodia



BAU = business as usual.

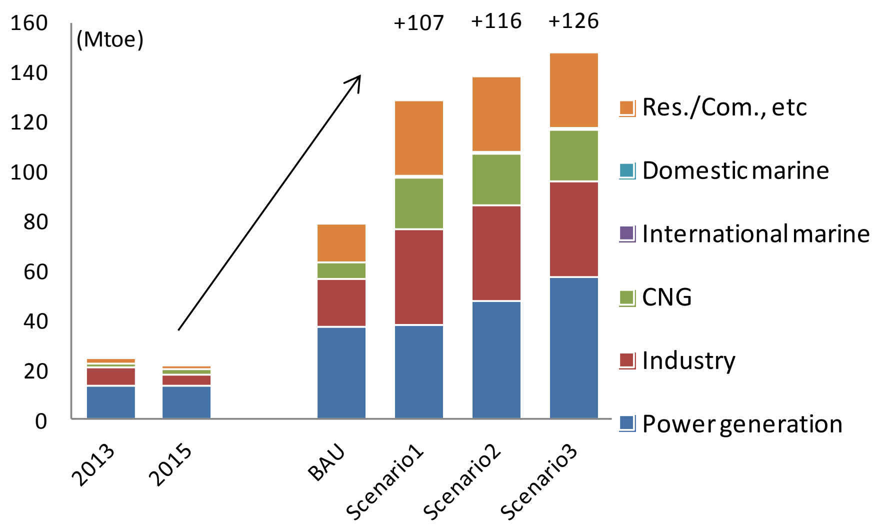
3.4 India

3.4.1 Potential demand for natural gas by sector

India's potential demand for natural gas is estimated to be up to 126 Mtoe/year more than its 2015 figures.

The highest potential demand for natural gas in India is represented by these sectors: power generation, industry, residential and commercial, and road transport (arranged in descending order).

Figure 3.8. Potential Demand for Natural Gas by Sector, India



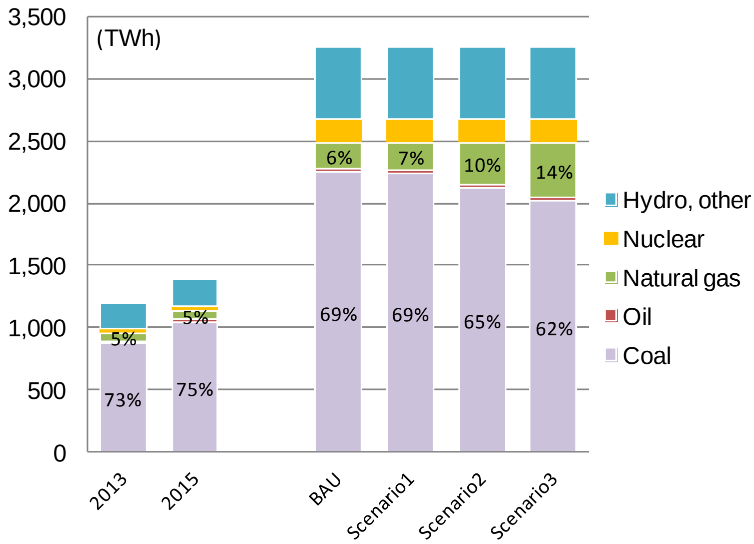
BAU = business as usual; CNG = compressed natural gas.

3.4.2 Power generation structure

In contrast to the power generation structure for the entire ASEAN region, the size of power generation in India is larger, but its share in natural gas power generation is smaller. The sensitivity analysis also shows that India's level of natural gas power generation under the BAU scenario is high. Therefore, to estimate the potential demand for natural gas in the power generation sector, the study made specific assumptions – i.e. assumptions different from those for the ASEAN nations.

Figure 3.9 shows the estimated power generation mix for India. Under Scenario 3, the calculated share of natural gas power generation reaches a maximum of 14%.

Figure 3.9. Power Generation Mix, India



BAU = business as usual.

3.4.3 Cost and CO_2 emission comparisons

Results show that India's fuel cost increases in all scenarios.

Since the power plant construction cost for GPP is lower than that for CPP, India will be better off under the three scenarios as compared to its BAU scenario.

Likewise, specific CO_2 emission will decrease under the three scenarios since the resulting emission numbers for GPPs are lower than those for CPPs.

Table 3.5. Cost and CO_2 Emission (Power Generation), India

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	+0.3	+0.2	+0.1	-0.0	-2.5 (+0%)
2	+6.4	+4.1	+1.7	-0.6	-58.6 (-3%)
3	+12.6	+8.0	+3.3	-1.1	-114.7 (-5%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

Meanwhile, in sectors outside the power generation sector, oil will be replaced by natural gas. Even at US$11.9/MMbtu (US$472/toe), the LNG price is still lower than the crude oil price (US$820 /toe), which therefore brings benefits to consumers. In addition, there will be less CO_2 emission from natural gas than from oil.

Table 3.6. Cost and CO_2 Emission (Other Sectors), India

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-10.4	-16.1	-22.0	-0.026 (-2%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

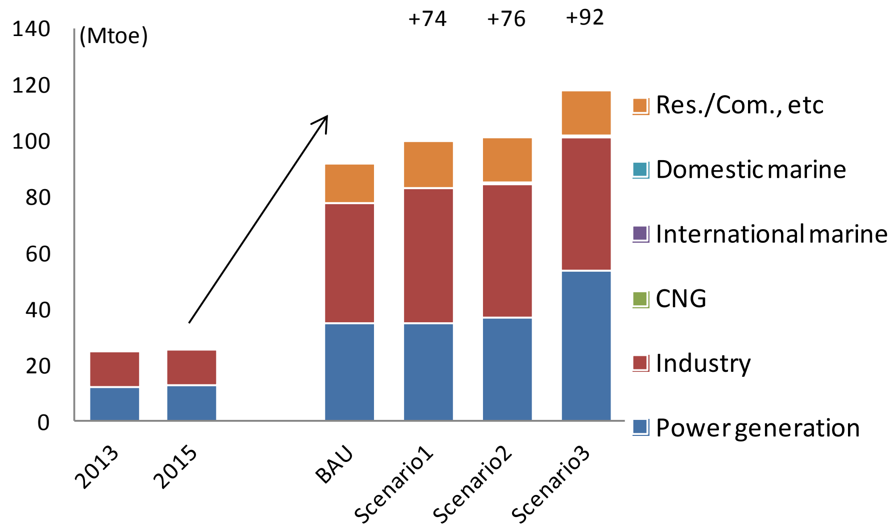
Assuming that the supply infrastructure has been put in place to meet the potential demand for natural gas, results under Scenario 3 show no benefit in terms of the total fuel cost when the LNG price is at its highest at US$11.9/MMbtu for the power generation sector and other sectors combined.

3.5 Indonesia

3.5.1 Potential demand for natural gas by sector

Indonesia's potential demand for natural gas is estimated to be larger by 92 Mtoe/year at best when compared with its figure in 2015. Its industry sector has the highest potential demand for natural gas, followed by the power generation sector.

Figure 3.10. Potential Demand for Natural Gas by Sector, Indonesia

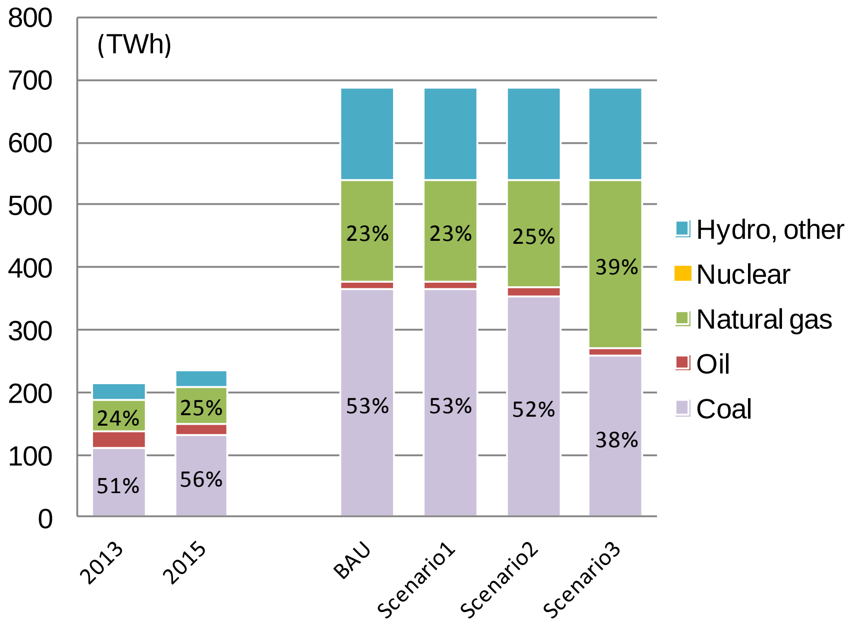


BAU = business as usual; CNG = compressed natural gas

3.5.2 Power generation structure

In Figure 3.11, the share of natural gas already reached 23% under the BAU scenario, and the assumption in Scenario 1 was the same as the BAU scenario. Under Scenario 3, results show that the share of natural gas power generation will reach 39%.

Figure 3.11. Power Generation Mix, Indonesia



BAU = business as usual.

3.5.3 Cost and CO_2 emission comparison

In the power generation sector, CPP and GPP are compared. Results show that Scenario 1 is the same as that of Indonesia's BAU scenario.

The heat efficiency of GPP is higher than of the CPP, while the required input energy of GPP is smaller than that of CPP. However, the coal price (US$125/toe) is very low even when compared with the lowest LNG price of US$6/MMbtu (US$238/toe). Therefore, fuel cost increases are expected under Scenarios 2 and 3.

Since the unit power plant construction cost with GPP is lower than with CPP, there will be a benefit under Scenarios 2 and 3.

Also, since the specific CO_2 emission with GPP is lower than CPP, CO_2 emissions are expected to lessen under Scenarios 2 and 3.

Table 3.7. Cost and CO_2 Emission (Power Generation Sector), Indonesia

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	-	-	-	-	-
2	+0.6	+0.4	+0.2	-0.1	-5.3 (-1%)
3	+5.8	+3.7	+1.5	-0.5	-53.1 (-13%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

Results show that in sectors other than the power generation sector, oil will be replaced by natural gas. Likewise, LNG prices are low. Even if the LNG price is at US$11.9/MMbtu (US$472/toe), it remains lower than the crude oil price (US$820/toe), allowing for a large advantage in terms of fuel costs. In addition, since the specific CO_2 emission of natural gas is less than oil, there will be less CO_2 emission.

Table 3.8. Cost and CO_2 Emission (Other Sectors), Indonesia

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-2.7	-3.6	-4.5	-0.004 (-1%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

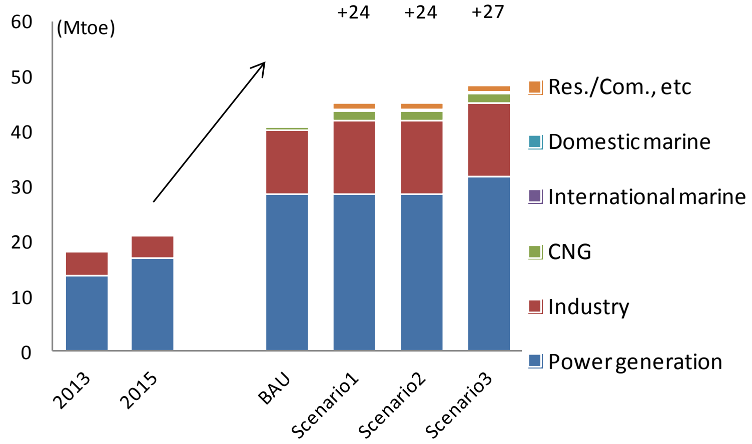
Even if all the potential demand for natural gas are met under Scenario 3, there will be no advantage in terms of the total fuel cost in cases where the LNG price is at its highest at US$11.9/MMbtu. This finding is based on calculations on the power generation sector and other sectors combined.

3.6 Malaysia

3.6.1 Potential demand for natural gas by sector

Estimates for Malaysia show that the potential demand for natural gas—excluding those for non-energy use and export—will be higher by up to 27 Mtoe/year compared to 2015 figures. The power generation sector has the highest potential demand for natural gas, followed by the industry sector.

Figure 3.12. Potential Demand for Natural Gas by Sector, Malaysia

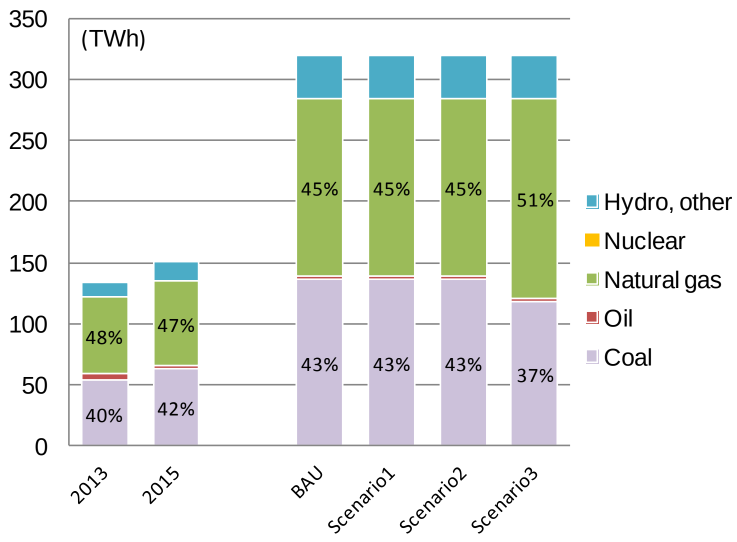


Notes: BAU = business as usual; CNG = compressed natural gas

3.6.2 Power generation structure

Malaysia is a natural gas-producing country, with its share of natural gas almost reaching 50% in 2015. While the share of natural gas decreased in the BAU scenario, Scenario 3 reveals a figure that will exceed the 2015 level. Scenarios 1 and 2 bear the same assumption as that under the BAU scenario.

Figure 3.13. Power Generation Mix, Malaysia



BAU = business as usual.

3.6.3 Cost and CO_2 emission comparisons

In the power generation sector, CPP and GPP are compared. Note that since Scenarios 1 and 2 are the same as the BAU scenario, the comparison showed no differences with regard the impact on either costs or CO_2 emissions.

The heat efficiency of GPP is higher than that of CPP, while the required input energy of GPP is smaller than CPP's. However, the coal price (US$125/toe) is very low even when compared to the lowest LNG price of US$6/MMbtu (US$238/toe) for this study. The fuel cost under Scenario 3 therefore increases.

Scenario 3 also shows some benefits on the construction cost and CO_2 emission since the construction cost of a GPP is lower than that of a CPP. The CO_2 emissions will likewise be lesser when GPP is opted over CPP.

Table 3.9. Cost and CO_2 Emission (Power Generation), Malaysia

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	-	-	-	-	-
2	-	-	-	-	-
3	+1.0	+0.6	+0.3	-0.1	-9.2 (-5%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

In sectors other than power generation, natural gas will replace oil. Even if the LNG price is US$11.9/MMbtu (US$472/toe), it is still lower than the crude oil price (US$820/toe). The specific CO_2 emission from natural gas will also be lesser compared to that from oil.

Table 3.10. Cost and CO_2 Emission (Other Sectors), Malaysia

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-1.4	-1.9	-2.4	-0.002 (-1%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

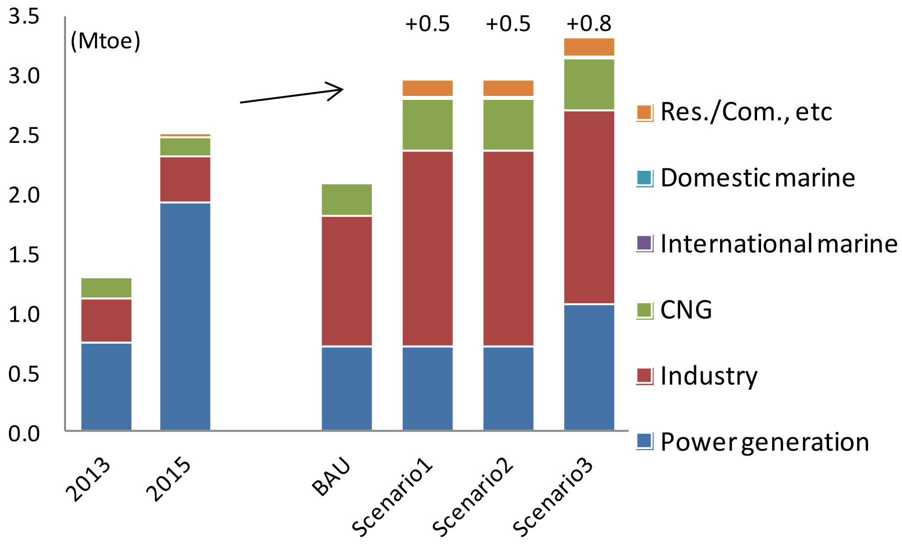
If the supply infrastructure is put in place to meet the potential demand for natural gas, some benefits may be expected in the total fuel cost even in cases where the LNG price is at its highest at US$11.9/MMbtu (Under Scenario 3, all sectors).

3.7 Myanmar

3.7.1 Potential demand for natural gas by sector

For Myanmar, estimates show that the potential demand for natural gas will be larger by up to 0.8 Mtoe/year in Scenario 3 compared to 2015 figures. Its industry sector presents the highest potential demand for natural gas, followed by the domestic power generation sector.

Figure 3.14. Potential Demand for Natural Gas by Sector (Myanmar)



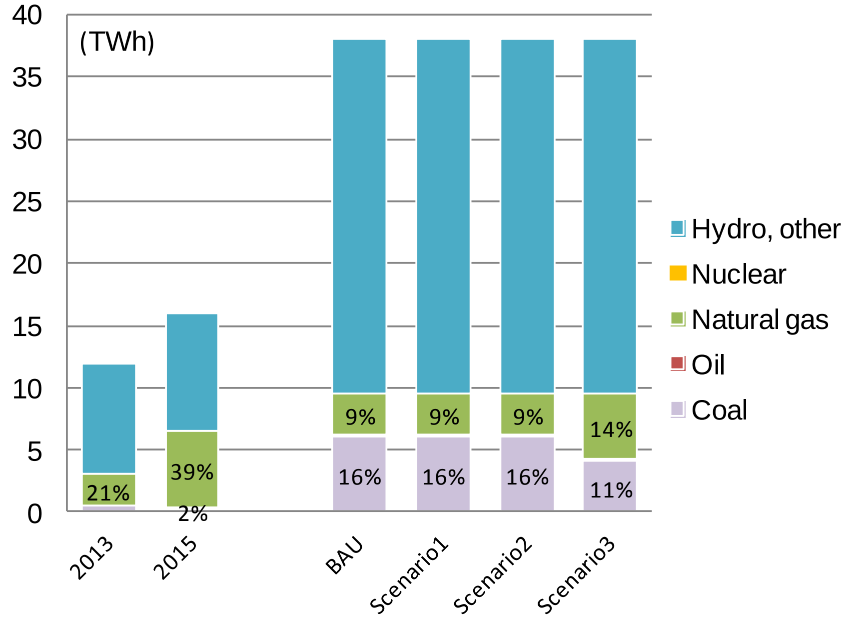
BAU = business as usual; CNG = compressed natural gas.

3.7.2 Power generation structure

Myanmar's share of natural gas in 2015 was 39%. However, under its BAU scenario, its share of natural gas is expected to decrease. Even Scenario 3 assumes that the share will be below the 2015 level. Meanwhile, Scenarios 1 and 2 have the same assumption as the BAU scenario.

Myanmar gets its main energy source from hydro power.

Figure 3.15. Power Generation Mix (Myanmar)



BAU = business as usual.

3.7.3 Cost and CO_2 emission comparisons

The CPP and GPP in Myanmar's power generation sector are compared, although note that since Scenarios 1 and 2 are the same as the BAU scenario, there should be no differences in the outcomes.

The heat efficiency of GPP is higher than CPP, and the required input energy of GPP is smaller than CPP. However, the coal price (US$125/toe) is already very low even when compared with LNG's lowest price of US$6/MMbtu (US$238/toe). Therefore, the fuel cost under Scenario 3 increases.

Since each GPP's construction cost is lower than that of the CPP, and CO_2 emission from GPP is lower than that from CPPs, Scenario 3 brings some benefit.

Table 3.11. Cost and CO_2 Emission (Power Generation), Myanmar

Scenario	**Fuel import cost**			**Construction cost** (US$ billion)	**CO_2 emission** (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	-	-	-	-	-
2	-	-	-	-	-
3	+0.1	+0.1	+0.03	-0.01	-1.0 (-15%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

Similar to the study's results on other countries, oil will be replaced by natural gas in Myanmar's sectors outside of power generation. Its LNG price, even at US$11.9/MMbtu (US$472/toe), is lower than that of the crude oil price (US$820 /toe). The specific CO_2 emission from natural gas is lesser than that from oil.

Table 3.12. Cost and CO_2 Emission (Other Sector, Total), Myanmar

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-0.3	-0.4	-0.5	-0.0004 (-3%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

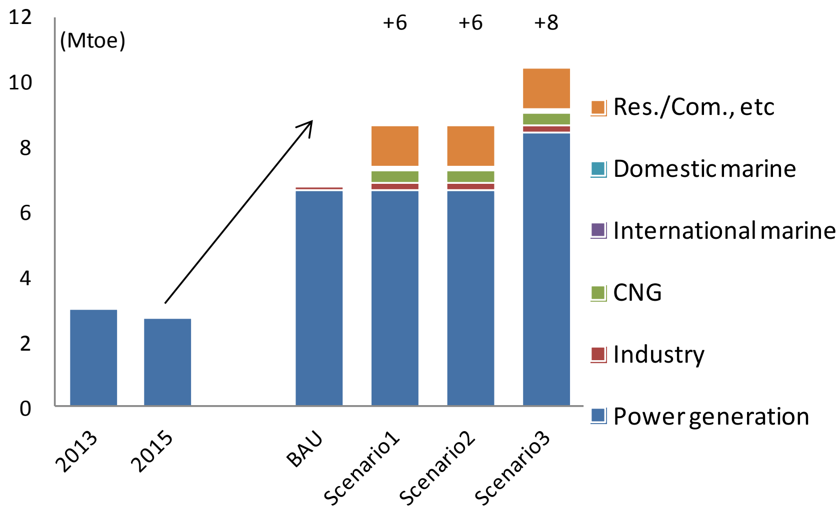
Assuming that Myanmar sets in place the supply infrastructure to meet all the potential demands for natural gas, the country can see some benefit from the total fuel cost (even if the LNG price is at US$11.9/MMbtu) in the power generation sector as well as other sectors under Scenario 3.

3.8 Philippines

3.8.1 Potential demand for natural gas by sector

The study estimates the Philippines' potential demand for natural gas to expand by up to 8 Mtoe/year as compared to its 2015 figures. The highest potential demand for natural gas comes from the power generation sector, followed by the residential and commercial sector.

Figure 3.16. Potential Demand for Natural Gas by Sector (Philippines)

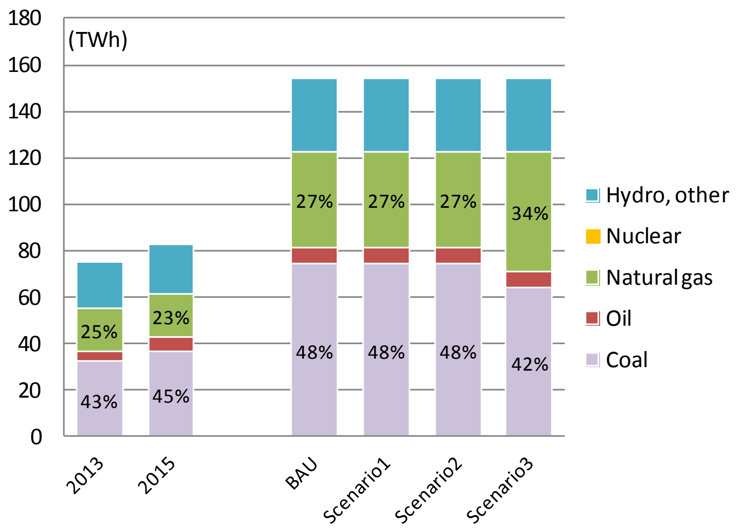


Notes: BAU = business as usual; CNG = compressed natural gas

3.8.2 Power generation structure

Results further show that the share of natural gas in the Philippines' power generation mix in 2015 was 23%. However, under the BAU scenario, the share of natural gas will increase to 27%. Furthermore, Scenario 3 assumes that the share will reach 34%. Scenario 1 and 2 have the same assumption as the BAU scenario.

Figure 3.17. Power Generation Mix, Philippines



BAU = business as usual.

3.8.3 Cost and CO_2 emission comparisons

In the power generation sector, the heat efficiency of GPP is higher than that of CPP, while the required input energy of GPP is smaller than that of the CPP. However, the coal price (US$125/toe) is significantly lower than the LNG's price (even at US$6/MMbtu (US$238/toe). Therefore, Scenario 3 shows an increase in fuel cost.

However, Scenario 3 sees lower construction costs as well as lesser CO_2 emission from GPP than from CPP.

Table 3.13. Cost and CO_2 Emission (Power Generation), Philippines

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	-	-	-	-	-
2	-	-	-	-	-
3	+0.6	+0.4	+0.1	-0.05	-5.1 (-15%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

In the country's other sectors, natural gas is seen to replace oil. Likewise, a large benefit is anticipated in terms of fuel costs since the LNG price of US$11.9/MMbtu (US$472/toe) is lower than that of crude oil (US$820 /toe). There will also be lesser CO_2 emission coming from natural gas than from oil.

Table 3.14. Cost and CO_2 Emission (Other Sectors), Philippines

Fuel import cost			**CO_2 emission** (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-0.6	-0.8	-1.0	-0.001 (-1%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

If the country meets the potential demand for natural gas, there will be a benefit in total fuel costs in all sectors (including the energy generation sector) if the LNG price is US$9/MMbtu or US$6/MMbtu. Where the LNG price is US$11.9/MMbtu, the increase in fuel cost in the power generation sector will be offset by the fuel cost reduction in other sectors.

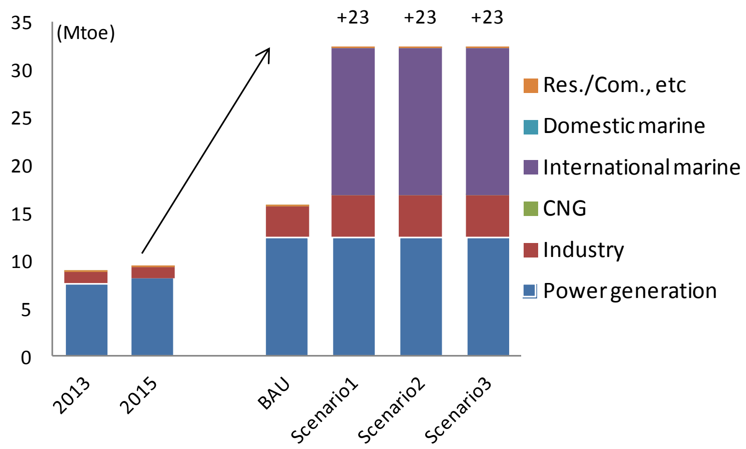
3.9 Singapore

3.9.1 Potential demand for natural gas by sector

Singapore's potential demand for natural gas is estimated to be larger by up to 23 Mtoe/year compared to the figures in 2015.

The international marine bunker sector has the highest potential demand for natural gas. Currently, Singapore has a large international bunker fuel market. The study assumes thus that the market in LNG bunkering will also exhibit significant growth in the future. In addition, the natural gas demand is expected to become stronger than the BAU scenario in the industry sector.

Figure 3.18. Potential Demand for Natural Gas by Sector, Singapore

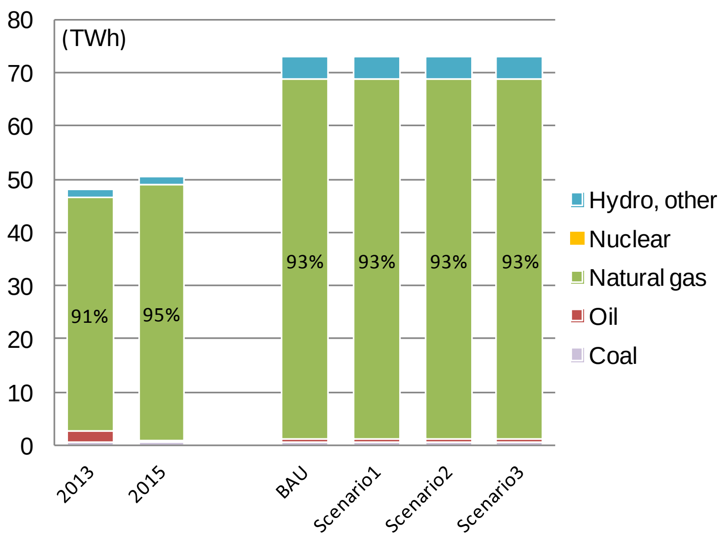


Notes: BAU = business as usual; CNG = compressed natural gas

3.9.2 Power generation structure

Results show that the share of natural gas in Singapore exceeds 90%, and Scenarios 1 to 3 are the same as the BAU scenario.

Figure 3.19. Power Generation Mix, Singapore



BAU = business as usual.

3.9.3 Cost and CO_2 emission comparisons

Singapore has a very high GPP ratio, and the potential demand for natural gas in the power generation sector corresponds to the BAU scenario. Therefore, only sectors other than the power generation sector are compared.

In sectors other than the power generation sector, natural gas will replace oil. A large benefit in fuel cost is anticipated as estimates show that LNG that is priced even at US$11.9/MMbtu (US$472/toe) is lower than the crude oil price (US$820/toe).The specific CO_2 emission coming from natural gas is also lesser compared to that from oil.

Table 3.15. Cost and CO_2 Emission (Other Sectors), Singapore

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-5.8	-7.7	-9.7	-0.008 (-6%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

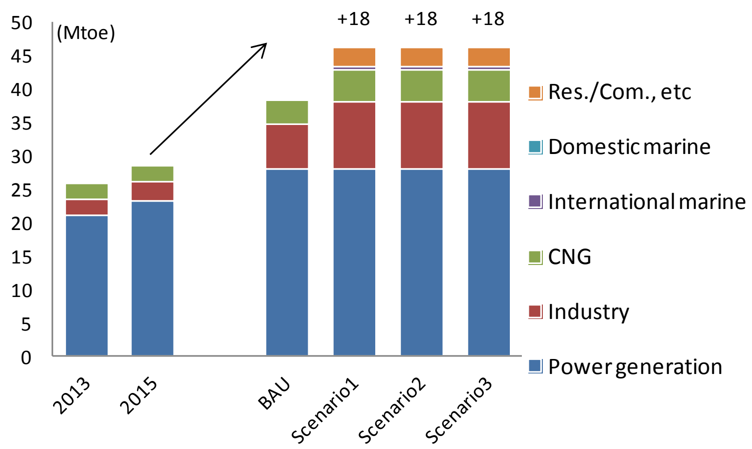
3.10 Thailand

3.10.1 Potential demand for natural gas by sector

Thailand's potential demand for natural gas is estimated to be larger by up to 30 Mtoe/year compared to 2015 figures.

Sector-wise, its power generation sector presents the highest potential demand for natural gas. However, since the share of natural gas in the total power generation is high, the potential demand for natural gas in Thailand's power generation sector remains the same as that under the BAU scenario. Higher potential demand for natural gas under the BAU scenario is assumed in the industry sector, road transport sector, and residential and commercial sector.

Figure 3.20. Potential Demand for Natural Gas by Sector, Thailand

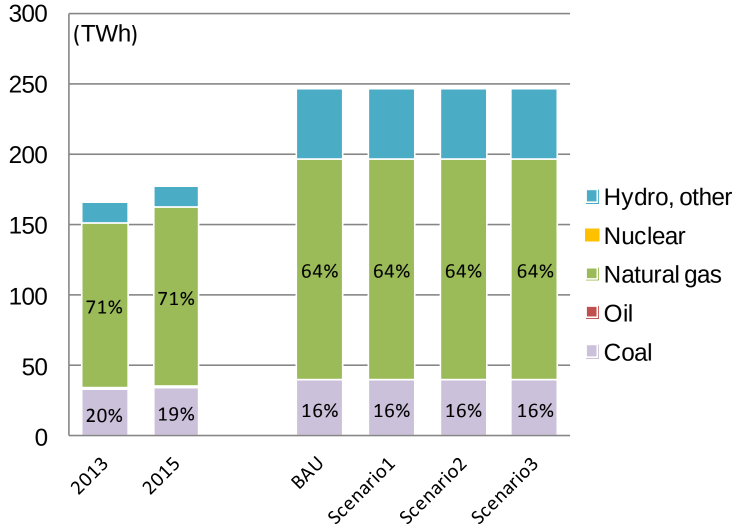


Notes: BAU = business as usual; CNG = compressed natural gas

3.10.2 Power generation structure

Figure 3.21 shows that the share of natural gas in 2013 was as high as 71%, and will be 64% in the BAU scenario for 2030. The potential demand for natural gas in the power generation sector in scenarios 1 to 3 is the same as the BAU scenario.

Figure 3.21. Power Generation Mix, Thailand



BAU = business as usual.

3.10.3 Cost and CO_2 emission comparisons

Thailand shows a very high GPP ratio, and the potential demand for natural gas in the power generation sector corresponds to the BAU scenario. Therefore, only sectors outside of the power generation sector are compared.

In other sectors (i.e. excluding the power generation sector), natural gas will replace oil. A large benefit in the cost of fuel is expected since the LNG price of US$11.9/MMbtu (US$472/toe) is lower than the crude oil price (US$820/toe). The CO_2 emission from natural gas is also lesser.

Table 3.16. Cost and CO_2 Emission (Other Sectors), Thailand

Fuel import cost			CO_2 emission (Million tons-CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-1.1	-2.0	-2.9	-0.005 (-2%)

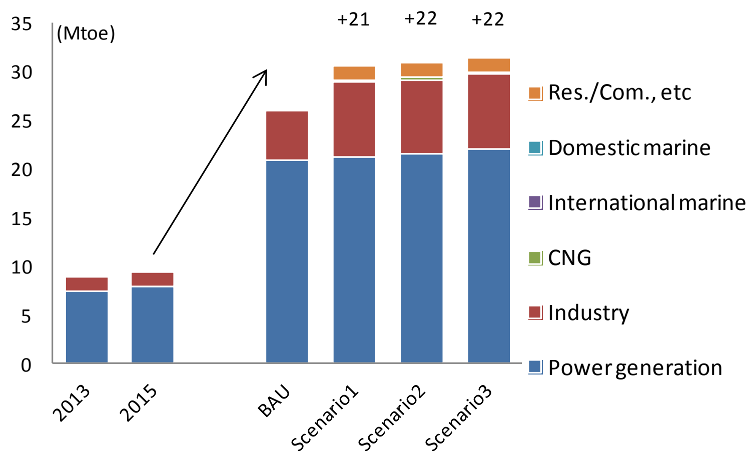
LNG = liquefied natural gas; CO_2 = carbon dioxide.

3.11 Viet Nam

3.11.1 Potential demand for natural gas by sector

Viet Nam's potential demand for natural gas is estimated to be larger by up to 22 Mtoe/year than its 2015 levels. The highest potential demand for natural gas comes from the power generation sector and the industry sector.

Figure 3.22. Potential Demand for Natural Gas by Sector, Viet Nam

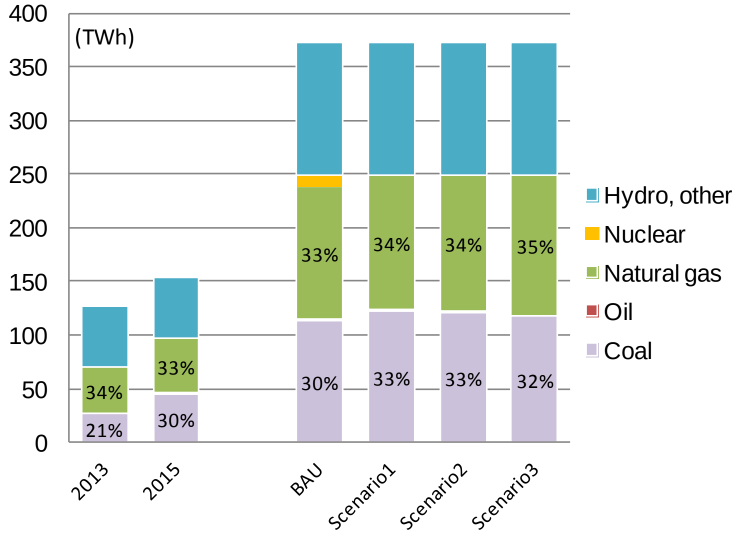


Notes: BAU = business as usual; CNG = compressed natural gas

3.11.3 Power generation structure

Viet Nam's BAU scenario assumes that an NPP will commence operation in 2028. However, in this study, the assumption used is that no NPP would commence operation even in 2030. Assuming further that the NPP power generation equivalent in the BAU scenario would be replaced by thermal power generation, the study's three scenarios allocate different mixes of coal and natural gas.

Figure 3.23. Power Generation Mix, Viet Nam



BAU = business as usual.

3.11.3 Cost and CO_2 emission comparisons

In the power generation sector, the heat efficiency of GPP is higher than CPP, while the required input energy of GPP is smaller than CPP. However, the coal price (US$125/toe) is significantly low when compared to even the lowest LNG price of US$6/MMbtu (US$238/toe). Therefore, the fuel cost increases under all this study's scenarios.

Since the cost of constructing a GPP is lower than that of the CPP, there are some gains under all scenarios.

As mentioned earlier, the increase in the construction cost under the BAU scenario is based on the assumption that Viet Nam's NPP will commence operation in 2028. However, under the three scenarios, the assumption is that no NPP will commence operation even in 2030. This is because the NPP power generation under the BAU scenario is anticipated to be replaced with thermal power generation. While neither CPP nor GPP are the equivalent of the NPP power generation, both are expected to increase on a net basis.

Note that since estimates on the NPP construction cost are difficult to draw, only the TPP construction cost is considered in this study.

The CO_2 emission decreases in all three scenarios when GPP is preferred more over CPPs. However, CO_2 emission as well as the construction cost climb once nuclear power generation becomes the option in Viet Nam.

Table 3.17. Cost and CO_2 Emission (Power Generation), Viet Nam

Scenario	Fuel import cost			Construction cost (US$ billion)	CO_2 emission (Million tons-CO_2)
	LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)		
1	+0.4	+0.3	+0.3	+0.1	+8.9 (+6%)
2	+0.5	+0.4	+0.3	+0.1	+8.1 (+5%)
3	+0.6	+0.5	+0.4	+0.1	+6.5 (+4%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

Meanwhile, in all other sectors, natural gas will replace oil. Even if the LNG is priced at US$11.9/MMbtu (US$472/toe), it remains lower than the crude oil price (US$820/toe). Aside from the lower fuel cost, the CO_2 emission from natural gas is also lesser than that from oil.

Table 3.18. Cost and CO_2 Emission (Other Sectors), Viet Nam

Fuel import cost			CO_2 emission (Million tons CO_2)
LNG: US$11.9/MMbtu (US$ billion)	LNG: US$9/MMbtu (US$ billion)	LNG: US$6/MMbtu (US$ billion)	
-1.5	-2.0	-2.5	-0.002 (-2%)

LNG = liquefied natural gas; CO_2 = carbon dioxide.

If all the potential demand for natural gas is met, an improved fuel cost is expected to benefit both the power generation sector and other sectors as a whole even at the LNG price of US$11.9/MMbtu.